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PCT WORLD INTELLECTUAL PROP
International E

INTERNATIONAL APPLICATION PUBLISHED UNDEI WO 9604935A1

(51) International Patent Classification 6 : A61L 2/10 | A1

(11) International Publication Number: WO 96/04935

(43) International Publication Date: 22 February 1996 (22.02.96)

(21) International Application Number: PCT/US94/10861

(22) International Filing Date: 26 September 1994 (26.09.94)

(30) Priority Data:
08/290,525 15 August 1994 (15.08.94) US

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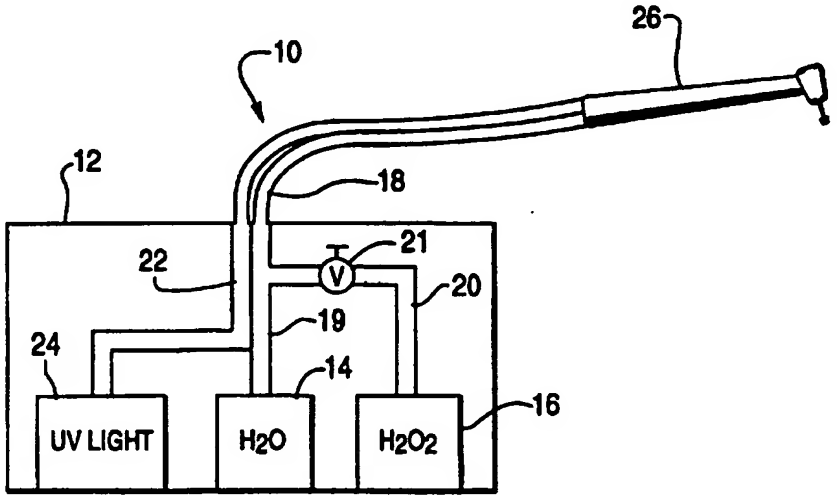
(81) Designated States: European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: STERILE WATER SUPPLY SYSTEM FOR DENTAL EQUIPMENT



(57) Abstract

A water supply system (10) particularly for use in dental equipment includes a waterline (18) and an ultraviolet light transmitting medium (22) extending along the length of the waterline (18). The light transmitting medium (22) may be attached along the outer surface of the waterline (18) with a window between the waterline (18) and the light transmitting medium (22) to allow ultraviolet light to pass from the medium (22) into the waterline (18). The light transmitting medium (22) may be embedded within the waterline (18) such that the ultraviolet light radiates in all directions from the medium (22) into the waterline (18). The waterline (18) may be embedded within the light transmitting medium (22) such that ultraviolet light radiates through the surface of the waterline (18). Hydrogen peroxide (16) is mixed with water (14) in the waterline (18) and radiated with ultraviolet light. This results in the sterilization of the waterline.

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STERILE WATER SUPPLY SYSTEM FOR DENTAL EQUIPMENT

Field of the Invention

The present invention relates to a sterile water supply system for use in dental equipment and, more particularly, to a water supply system using ultraviolet light and hydrogen peroxide to prevent growth in water supply lines of microbiota, such as bacteria, viruses. etc.

Background of the Invention

Many dental delivery systems, commonly used by dentists for a variety of procedures, are of similar basic design. Referring to Fig. 1, these delivery systems consist of a base unit 58 and one or more hand-held units 60. The base unit provides power 62, water 64 and control functions 66 to the hand-held units 60. A variety of tips 68 can be placed on the hand-held units, depending upon the treatment the dentist is using. It is obviously important to ensure elimination of cross contamination by rendering the instruments attached to these lines sterile, particularly the hand-held units which are placed in the patient's mouth. Most dental tools are disconnectible and sterilizable, but the water lines are not. Fouling of water lines can cause microbial organisms to be distributed to sterilized dental tools before the dental tools are even used.

Despite adequate sterilization method for most hand held tools, microbial fouling of the waterlines in these dental systems is an ongoing problem. Studies dating back over 30 years

have shown the presence of bacterial biofilms,i.e. colonies of microorganisms that attach to surfaces that are bathed with liquids, in dental unit waterlines. These same bacteria may be found in municipal water systems, in individual homes, in hospitals or any place with stagnant water. Also, the water in the waterlines is exposed to air born contaminants from dental operatory and such back retention from the patient's mouth. This contamination consists of blood, saliva, carious and normal tooth structure, and various micro organisms existing in the mouth of the patient.

The narrow tubing in dental delivery systems provides an ideal home for bacteria to thrive in biofilms. Because of the physical characteristics of water flow, the water in contact with the tubing surface is stationary. As a result, flushing dental systems with water does nothing to reduce or disturb the biofilm.

A possible solution to this problem is to use a sterile water supply. However, as soon as the water is exposed to air, it ceases to be sterile. Also, the sterile water will become contaminated once it passes through the waterlines.

The use of ultraviolet light is increasing as a general method of water sterilization. Ultraviolet radiation in the 200-300nm wavelength region can inactivate bacteria, protozoa, viruses, fungi, yeasts and algae although the resistance to ultraviolet radiation varies between organisms. At sufficiently high radiation doses all contaminants can be completely destroyed. It is easy to use and avoids the residues and potential by-products that arise from conventional chemical treatments.

However, ultraviolet light treatment requires adequate residence time of the water in the ultraviolet zone as well as good transmission through the water layer. Transmission is reduced by suspended matter in the water and the energy level decreases as the ultraviolet lamp ages, until it has to be replaced. Also, although ultraviolet light treatment may sterilize the water, in a dental water delivery system it is the surface of the pipes and tubing carrying the water that become contaminated, especially when the water is not flowing. The ultraviolet light treatment does not provide a satisfactory method of sterilizing the surface of the water pipes and tubes.

In this respect, chemical treatments do have advantages over ultraviolet radiation treatments. The chemicals persist in the water after the direct exposure time, which is inevitably short. Chemical treatments are also unaffected by water opacity. Hydrogen peroxide is an acceptable treatment but, used on its own, requires a high concentration to guarantee effectiveness and the residual peroxide level normally makes it an unacceptable treatment for drinking water.

United States Patent 4,289,728, issued September 15, 1981 to Peel and Waites entitled "Improvements in Methods of Sterilization", describes a method of treating water with a combination of ultraviolet light and hydrogen peroxide. The combination of the two methods retains the advantages of each, while disinfection rates are achieved that are better than either on their own. The disadvantages are overcome by allowing the use of lower concentrations of hydrogen peroxide, negating the effect of water opacity and reducing the time required for the water to

remain in the ultraviolet zone.

One application of this method would be the sterilization of waterlines in dental delivery systems. However, as seen in Fig. 1, the waterline of a hand-held dental device is not easily accessible. The majority of the waterline is contained inside the opaque tubing leading to and inside the base unit, and a flexible tube terminating at the connection to the dental tool. Therefore it would be desirable to have a waterline combined with an ultraviolet light source which would fit inside the waterline system and the base unit, to provide the necessary components for effective sterilization of the waterline using the method described above. Also, although the above discussion has been with regard to the maintaining of sterile water system in a dental supply system, similar problems exist in the water systems of other types of industry, such as in the water supply system for food processing and pharmaceutical processing.

Summary of the Invention

The present invention is directed to a water supply system which comprises a waterline, means for selectively providing hydrogen peroxide to the waterline, and an ultraviolet light emitting medium extending along at least a portion of the length of the waterline such that ultraviolet light can pass from the medium into the waterline.

The present invention is also directed to a method of sterilizing a dental water supply system in which water is fed through a waterline to a dental device. The method comprises selectively providing hydrogen peroxide into the water in the

waterline, and subjecting the water and hydrogen peroxide solution to ultraviolet light.

Brief Description of the Drawings

Fig. 1 is a schematic drawing of a typical dental delivery system.

Fig. 2 is schematic drawing of a dental delivery system containing a form of the water supply system of the present invention.

Fig. 3 is a side plan view of a typical hand-held dental unit.

Fig. 4 is a cross-sectional view taken along line 4-4 of Fig. 3.

Fig. 5 is a perspective view of another form of the present invention.

Fig. 6 is a perspective view of a third form of the present invention.

Detailed Description of the Drawings

Referring to Fig. 2, there is shown a schematic view of one form of the water supply system 10 of the present invention. The water supply system 10 includes a base unit 12, a water source 14 and a hydrogen peroxide source 16, both connected to a waterline 18 through lines 19 and 20 respectively. A valve 21 is provided in line 20 for controlling the flow of hydrogen peroxide into the system. Attached along the length of the waterline 18 is a light emitting medium 22, such as an optical fiber. To carry ultraviolet light, the optical fiber 22 may be

made of quartz. The optical fiber 22 is attached to an ultraviolet light source 24, contained within the base unit 12. The waterline 18 and the light emitting medium 22 continue through the base unit 12 and are connected at the other end away from the base unit to one or more hand held units 26.

Referring to Fig. 3, there is shown a schematic view of the hand-held dental unit 26 which is used with the water supply system 10 of the present invention. The waterline 18 is attached along its length to the ultraviolet light emitting medium 22, such as an optical fiber. The waterline 18 and the light emitting medium 22 continue through the handle 28 of the hand-held unit to the tip 30.

Referring to Fig. 4, the waterline 18 is attached along a surface 32 to the light emitting medium 22, such as an optical fiber. There is a window area 34 that runs along the length of the waterline 18 at the surface 32, adjacent to the light emitting medium 22. This window area 34 is of a material transparent to ultraviolet light, such as quartz, to allow ultraviolet light from the light emitting medium 22 to penetrate through the waterline 18 and into any liquid contained in the waterline 18.

The waterline 18 may be made from any flexible material. It is preferable that the material be plastic. The waterline 18 may be opaque or translucent to ultraviolet light, except for the window area 34, which is transparent to ultraviolet light.

As shown in Fig. 5, there is another form of a water supply system 36 of the present invention. The water supply system 36 comprises a waterline 38 which is embedded within a light

emitting medium 40. The waterline 38 is made of a flexible material which allows light from the light transmitting medium 40 to pass through the waterline 38 and into the liquid within the waterline 38. The light emitting medium 40 may be designed such that ultraviolet light will radiate only towards the embedded waterline 38, with no light radiating external from the light embodying medium 40. At least a portion of the waterline 38 is transparent to ultraviolet light.

Referring to Fig. 6, there is shown another form of a water supply system 42 of the present invention. A light emitting medium 44, such as an optical fiber, is embedded within a waterline 46. Ultraviolet light from the light emitting medium 44 radiates in all directions into the fluid running through the waterline 46. The outer surface 48 of the waterline 46 may be completely opaque to ultraviolet light.

In order to sterilize the water supply system including the inner surface of the waterline, hydrogen peroxide is mixed with the water in the waterline. The concentration of the hydrogen peroxide can be controlled through the use of the valve system 21 in Fig. 2. As described in United States Patent No. 4,289,728, the concentration of hydrogen peroxide should be no greater than 10% by weight, and preferably no greater than 3% by weight. The ultraviolet light source 24, as shown in Fig 2. is turned on. As also described in United States Patent No. 4,289,728, the wavelength of the ultraviolet light should be wholly or predominantly below 325nm. Ultraviolet light radiates from the light emitting medium attached to the light source into the waterline containing the water-hydrogen peroxide mixture,

resulting in the sterilization of the waterline. The low concentration of hydrogen peroxide is required to provide a low concentration of radicals which result in sterilization when subjected to the ultraviolet light. At higher concentrations of hydrogen peroxide, there is provided a higher concentration of radicals which tend to recombine with each other rather than result in sterilization. The hydrogen peroxide is then shut off, and the waterline may be flushed with pure water.

Thus there is provided by the present invention a water supply system for use in dental delivery units which contains both an ultraviolet light and a source of hydrogen peroxide. Although the hydrogen peroxide and ultraviolet light may be introduced at one end of the water supply system, its threshold value is sufficient to result in sterilization along the entire length of the supply system. This provides the ability to kill organisms in the system and thereby sterilize the waterlines of the dental delivery unit quickly and efficiently. The combination of ultraviolet light hydrogen peroxide provides more thorough decontamination of the waterlines than using either method alone. The system may be sterilized at the convenience of the operator. The operator, whether dentist or technician, can be sure of using a sterile water supply for each patient. Also, this water system sterilization can be used for water supply systems in other industries, such as in the food processing and pharmaceutical processing industries.

What is claimed is:

1. A water supply system comprising:

a waterline;

means for providing hydrogen peroxide to the waterline; and

an ultraviolet light transmitting medium extending at least partially along the waterline such that light is transmitted from the medium into the waterline.

2. The device of claim 1 wherein the light transmitting medium is an optical fiber.

3. The device of claim 2 wherein the light transmitting medium is attached along its length to the outer surface of the waterline.

4. The device of claim 3 wherein the waterline has a window therethrough to allow the passage of ultraviolet light from the light transmitting medium to the interior of the waterline.

5. The device of claim 4 wherein the waterline is opaque to ultraviolet light on all areas except for the window.

6. The device of claim 5 wherein the waterline is made of a flexible material.

7. The device of claim 2 wherein the light transmitting medium is embedded within the waterline.

8. The device of claim 7 wherein the light transmitting medium is designed to radiate ultraviolet light in all directions.

9. The device of claim 8 wherein the exterior surface of the waterline is opaque to ultraviolet light.

10. The device of claim 2 wherein the waterline is embedded within the light transmitting medium.

11. The device of claim 10 wherein the light transmitting medium is designed to radiate ultraviolet light only towards the embedded waterline.

12. The device of claim 11 wherein the waterline is transparent to ultraviolet light.

13. A method of sterilizing a dental supply system in which water is fed through a waterline to a dental device comprising:

selectively providing hydrogen peroxide into the water in the waterline; and

subjecting the water and hydrogen peroxide solution to ultraviolet light.

14. The method of claim 13 in which the amount of hydrogen peroxide provided in the water is sufficient to provide a concentration of hydrogen peroxide of no greater than 10% by weight.

15. The method of claim 14 in which the concentration of hydrogen peroxide in the water is no greater than 3% by weight.

16. The method of claim 14 in which the ultraviolet light is provided by passing it through a window in the waterline.

17. The method of claim 14 in which the ultraviolet light is provided by passing it into the water and hydrogen peroxide solution from within the waterline.

18. A water supply system comprising:

a waterline;

means for providing hydrogen peroxide to the waterline;

an ultraviolet light transmitting medium extending at least partially along the waterline such that light is transmitted from the medium into the waterline; and

a source of ultraviolet light coupled to the light trasnmitting medium.

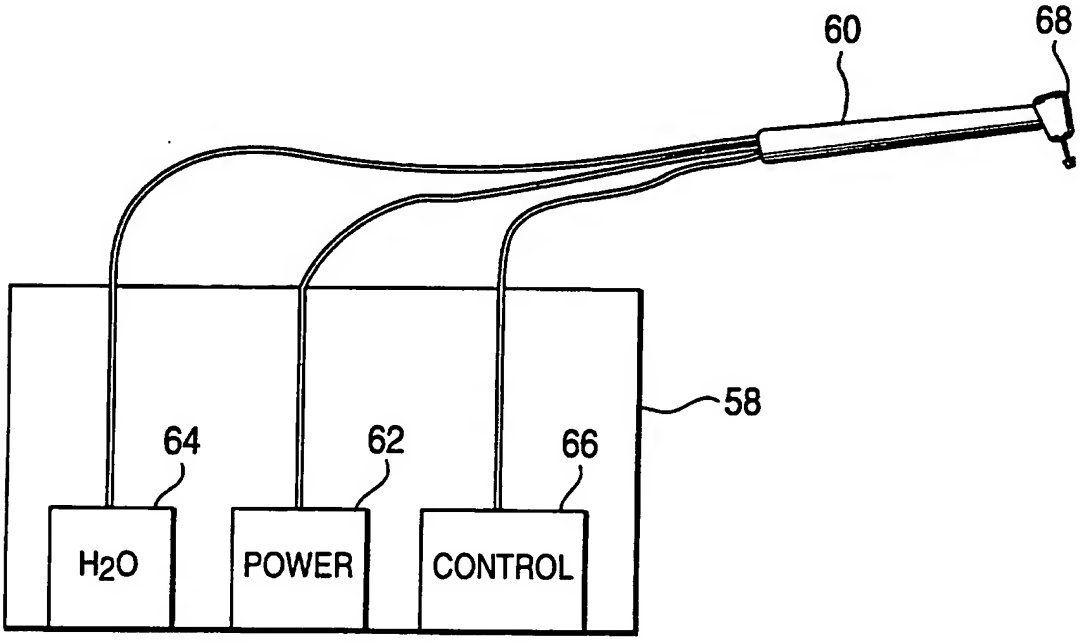

FIG. 1
PRIOR ART

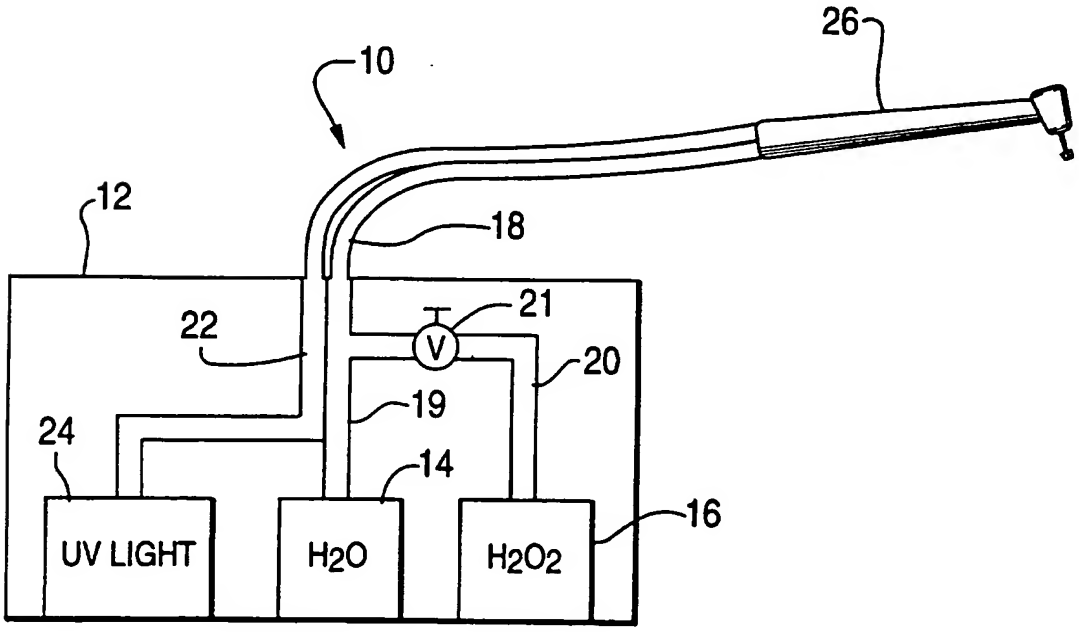

FIG. 2

ANY REFERENCE TO FIGURES 3, 4, 5, OR 6
SHALL BE CONSIDERED NON-EXISTENT.
(See Article 14(2))

INTERNATIONAL SEARCH REPORT

Int..ational application No.
PCT/US94/10861

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61L 2/10
US CL :422/24, 28, 186.3, 292; 250/436
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 422/24, 28, 186.3, 292, 905; 250/436 ; 433/29

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms:ultraviolet, hydrogen peroxide, water, disinfect, sterilize, optical fiber, fiber optic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,012,321 (KOUBEK) 15 March 1977, fig. 1, col. 5, lines 11-12 and 16 .	1, 13, 18
X	US, A, 5,244,570 (SMITH,II) 14 September 1993, fig. 1, col. 3, lines 35-40 and 54-56.	1, 13, 18
X -- Y	US, A, 4,289,728 (PEEL ET AL.) 15 September 1981, col. 1, lines 19-27, col. 2, lines 3-5, abstract.	13-15 -------- 16-17
X -- Y	US, A, 5,320,749 (MULLEN) 14 June 1994, col. 1, line 20, col. 3, lines 27-31, col. 6, lines 61-62, col. 9, lines 5-10.	1, 13, 18 ---------- 2-12

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,262,066 (VAN SOYE ET AL.) 16 November 1993, col. 1, lines 48-53, col. 2, lines 23-29 and 34-36, col. 3, lines 30-31, col. 4, lines 3-11, 45-48, and 59-64, col. 5, lines 1-15, 19-22, and 65-66, col. 6, lines 61-62.	1-12, 16-18